

Characterization of PM Dynamics for CCOS/CRPAQS Domain

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CCOS/CRPAQS TC Kickoff Meeting
December 15, 2009



Overview

- Study Goals
- Surface Wind Field Clustering
- Bay Area PM Clustering Results
- Cluster Analysis for CCOS Domain Project
 - Project Work Plan
 - Recent Progress and Future Work



Goals of the Study

- To identify and label domain-wide winter-time meteorological regimes
 - Perform surface wind field clustering.
 - Develop physical characterization of clusters.
- To infer the winter PM response to identified meteorological conditions
 - Infer physical mechanisms affecting PM levels.
 - Characterize evolution of individual species under regimes of interest.



Surface Wind Field Clustering

- Requires continuous, hourly surface wind data
 - Spatially representative
 - Temporally complete
- Labels each day based upon diurnal air flow
 - Indicates mesoscale flow patterns
 - Identifies synoptic regimes
 - Allows inference of criteria pollutant response to meteorology



Previous Contract – 061CCOS

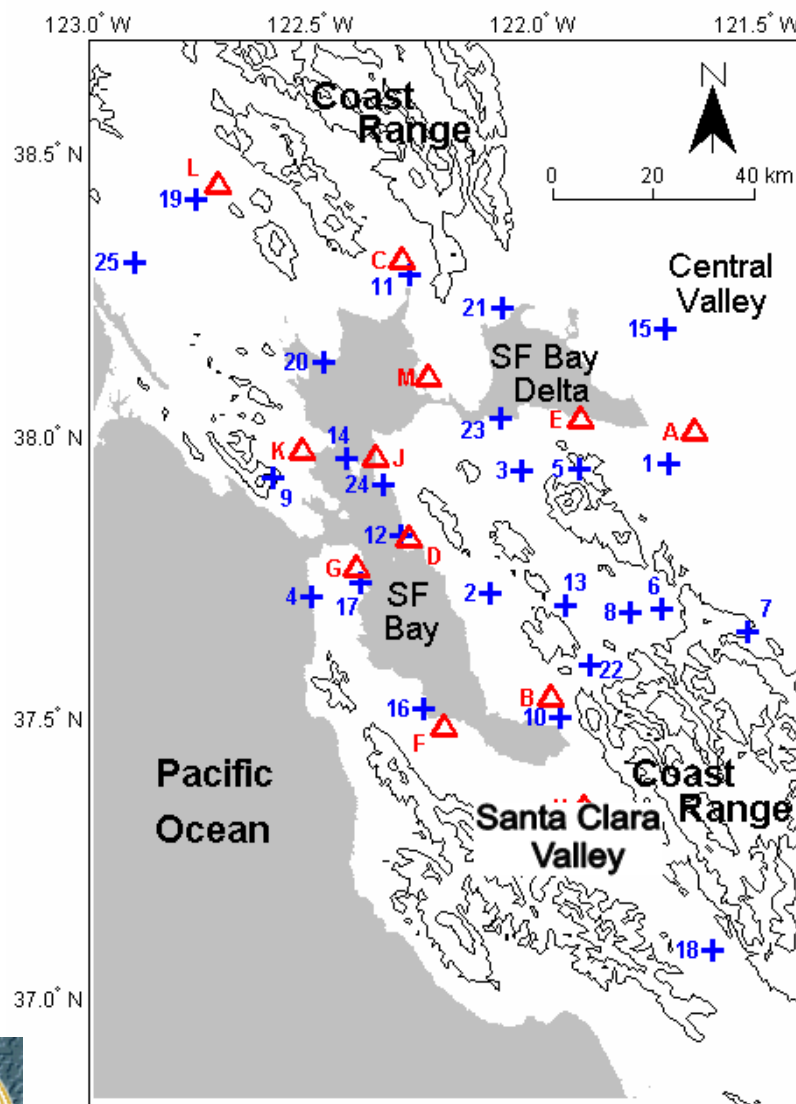
- Statistical clustering and sequencing algorithms applied to surface wind measurements.
- Characterized episodic meteorological conditions for 6 CCOS subregions
 1. San Francisco Bay Area (SFBA)
 2. North, Central and Southern San Joaquin Valley (N-SJV, C-SJV & S-SJV).
 3. Sacramento Valley and Mountain Counties (SV & MC).
- Explored CCOS domain-wide Inter-basin meteorological transport impacts on ozone levels.
- Cluster analysis provided considerable insight into weather patterns during Central California summer ozone season.



Pilot Study: Bay Area PM



San Francisco Bay Area, CA



Meteorological Stations (+)

- 1 Bethel Island
- 2 Chabot
- 3 Concord
- 4 Fort Funston
- 5 Kregor Peak
- 6 Livermore Lab
- 7 Livermore Lab Site-300
- 8 Livermore Rincon
- 9 Mt. Tamalpais
- 10 NUMMI
- 11 Napa STP
- 12 Oakland STP
- 13 Pleasanton STP
- 14 Pt. San Pablo
- 15 Rio Vista
- 16 San Carlos
- 17 San Francisco STP
- 18 San Martin APT
- 19 Santa Rosa APT
- 20 Sonoma Baylids
- 21 Suisun STP
- 22 Sunol
- 23 Tesoro(Golden Eagle)
- 24 UC Richmond
- 25 Valley Ford

PM Monitors (Δ or +)

| | BAM | PM _{2.5} | PM ₁₀ |
|-------------------|-------|-------------------|------------------|
| A Bethel Island | | | 6-day |
| 2 Concord | | 1-day | 6-day |
| B Fremont | | 3-day | 6-day |
| 8 Livermore | 1-day | 3-day | 6-day |
| C Napa | | | 6-day |
| D Oakland | 1-day | | |
| E Pittsburg | | | 6-day |
| F Redwood City | 1-day | 3-day | 6-day |
| G San Francisco | 1-day | 1-day | 6-day |
| H San Jose-4th St | 1-day | 1-day | 6-day |
| I San Jose-Tully | | 1-day | 6-day |
| J San Pablo | | | 6-day |
| K San Rafael | | | 6-day |
| L Santa Rosa | | 3-day | 6-day |
| M Vallejo | 1-day | 3-day | 6-day |



Meteorological and Air Quality Data

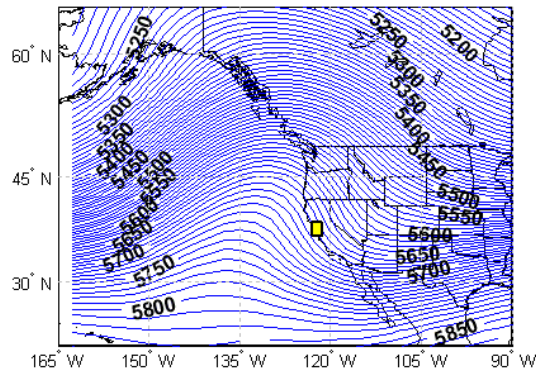
- Wind data
 - Study period: 1996-2007 (Nov 1 – Mar 31)
 - 26 sites monitoring wind speed and direction
- PM data
 - PM_{2.5} and PM₁₀ measurements available on a 3-day or 6-day schedule
 - Speciated PM_{2.5} data at San Jose on a 6-day schedule
- Other data
 - Surface temperature and precipitation data
 - NCEP/NCAR Reanalysis weather maps



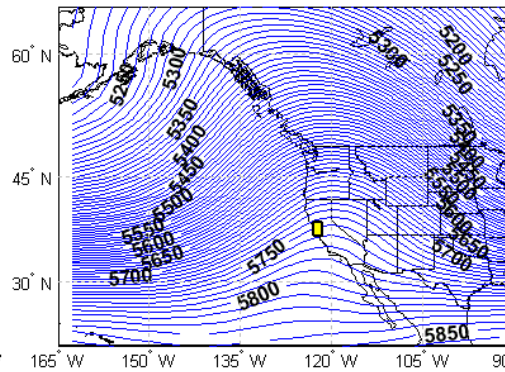
500-hPa Cluster Composites

Anticyclonic Clusters

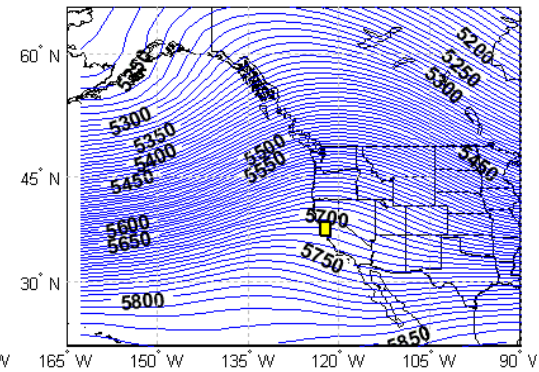
R1 (offshore ridge)
219 days



R2 (shoreline ridge)
422 days

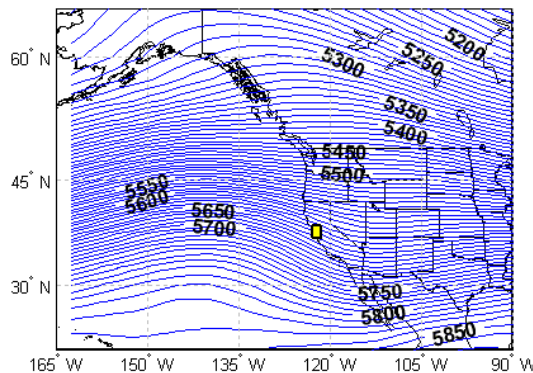


R3 (weakened ridge)
279 days

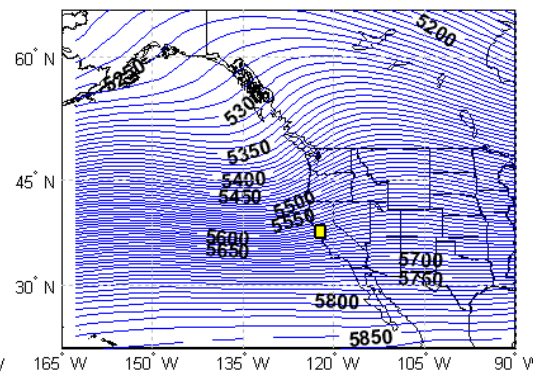


Cyclonic Clusters

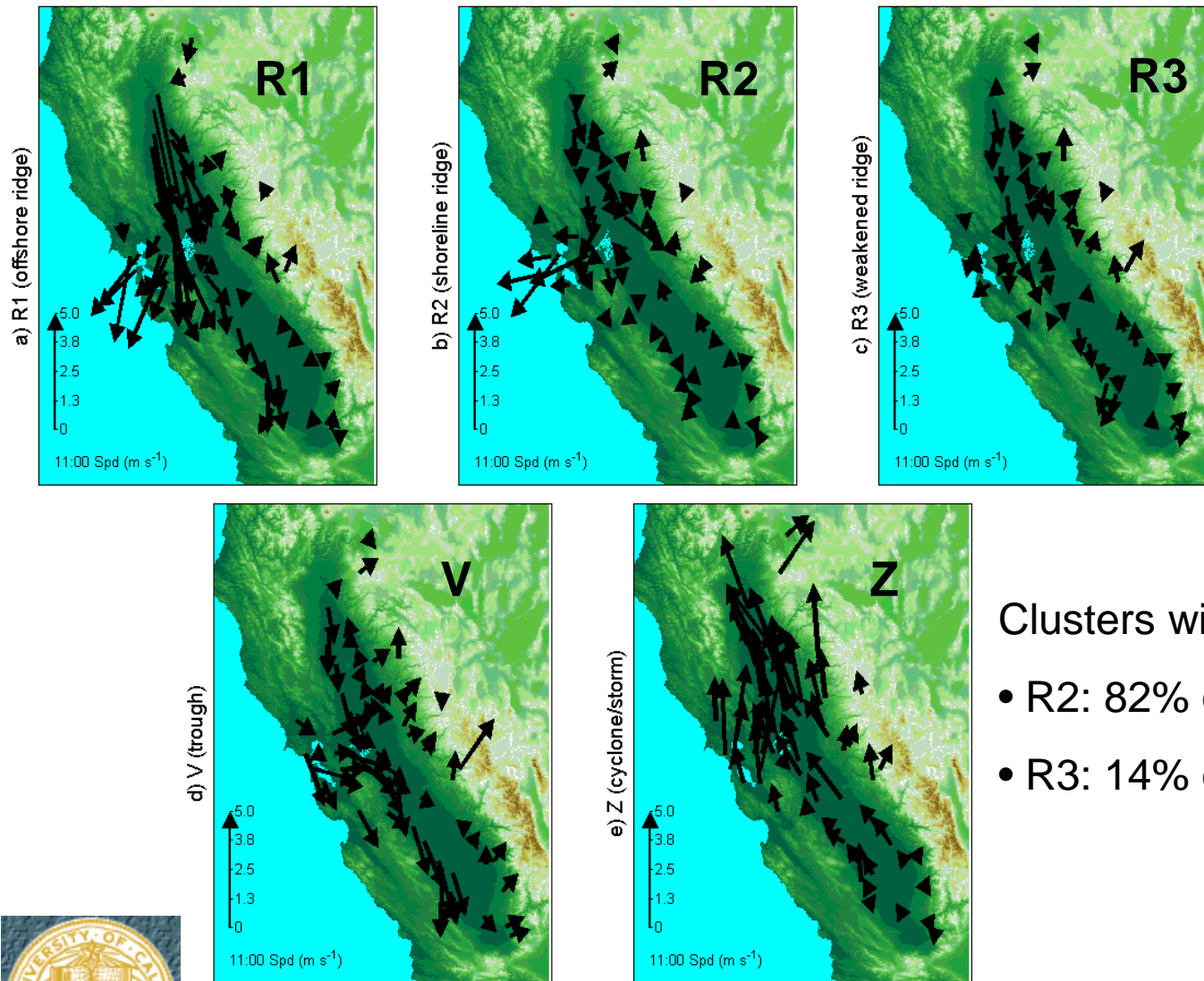
V (trough)
413 days



Z (cyclone/storm)
489 days



Surface Air Flow Patterns for Clusters

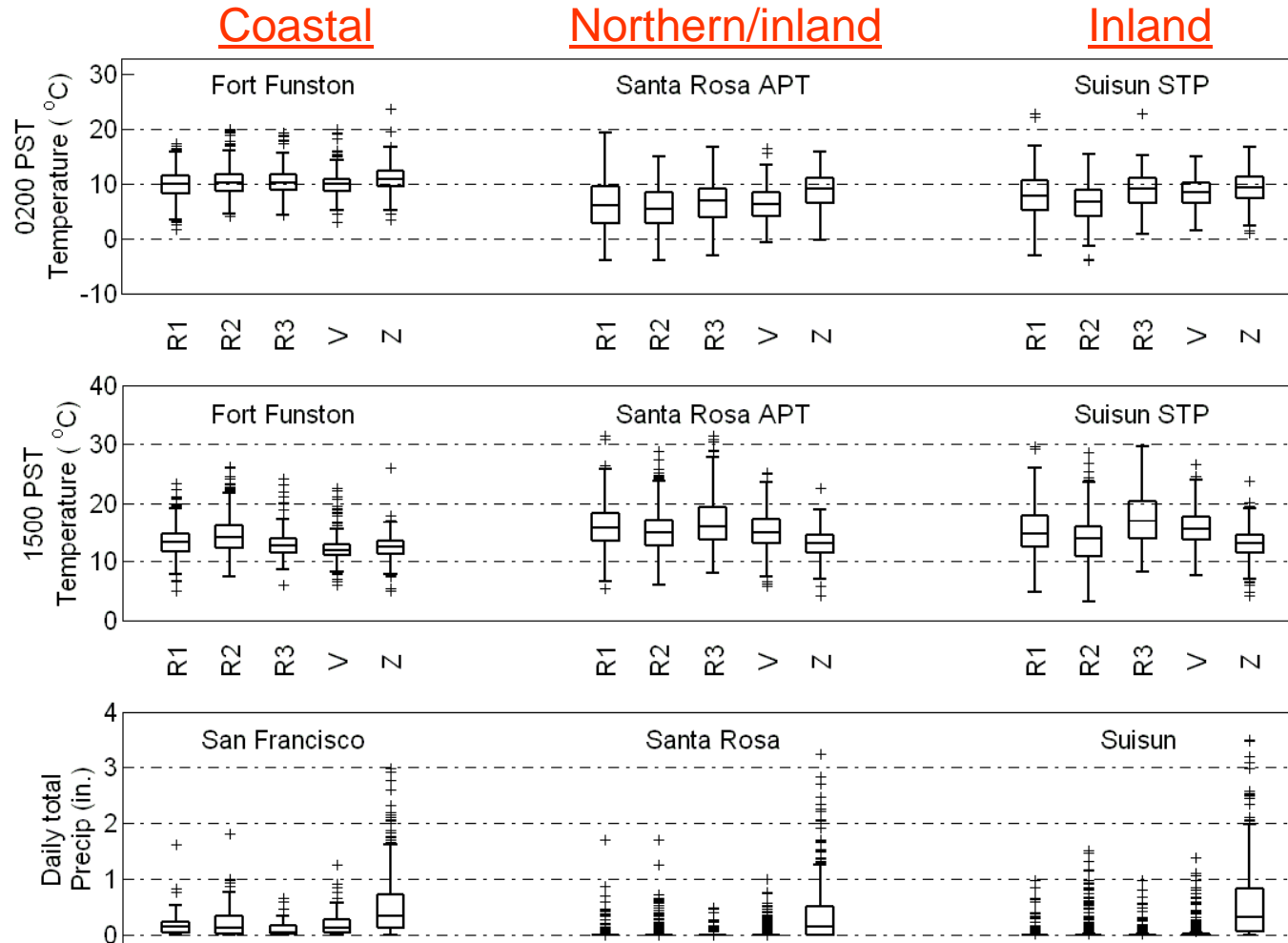


Clusters with PM_{2.5} exceedances

- R2: 82% of days
- R3: 14% of days



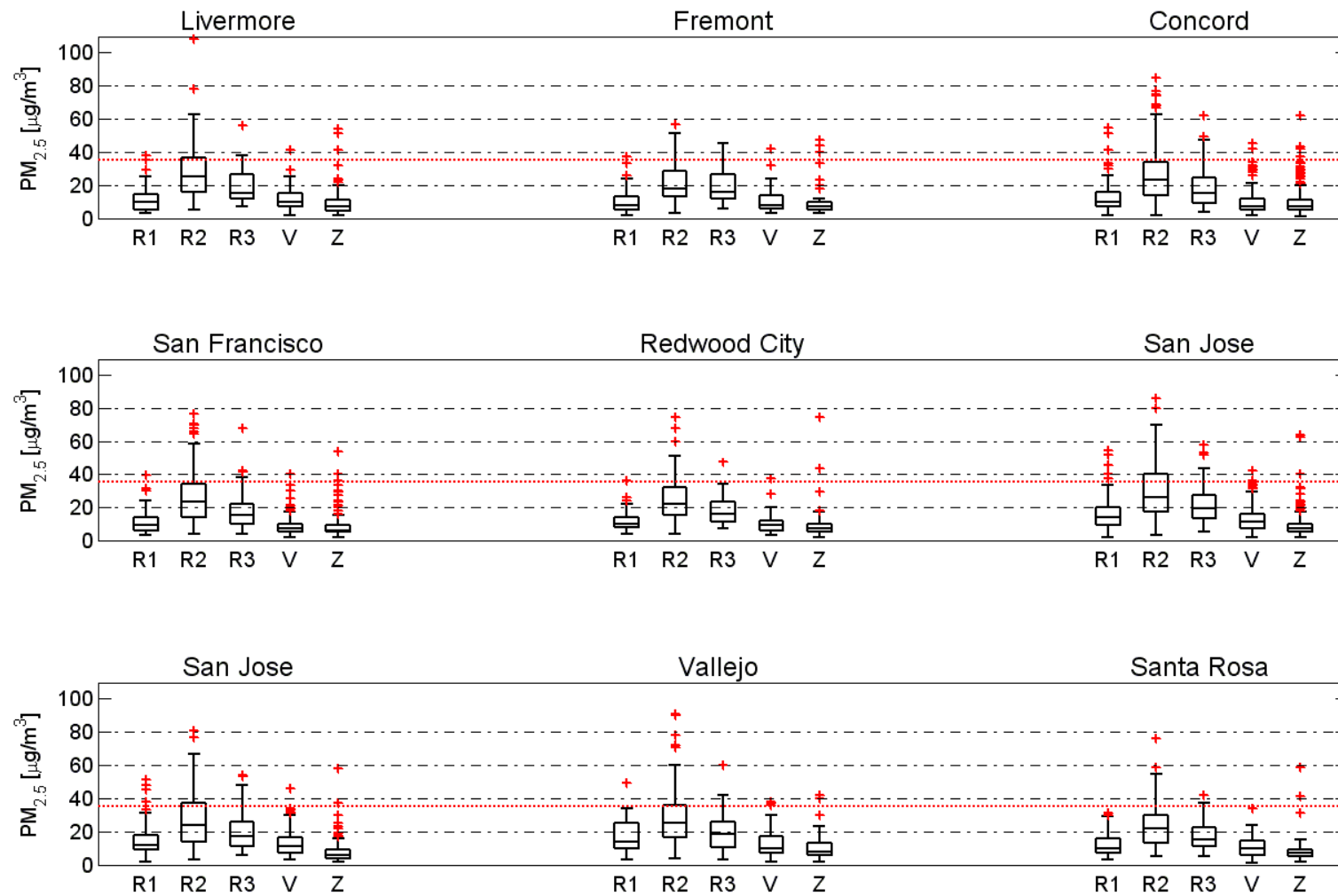
Temperature and Precipitation by Cluster



- R2 has reduced overnight temperatures at inland sites
- Z accounts for most of the annual precipitation in the Bay Area



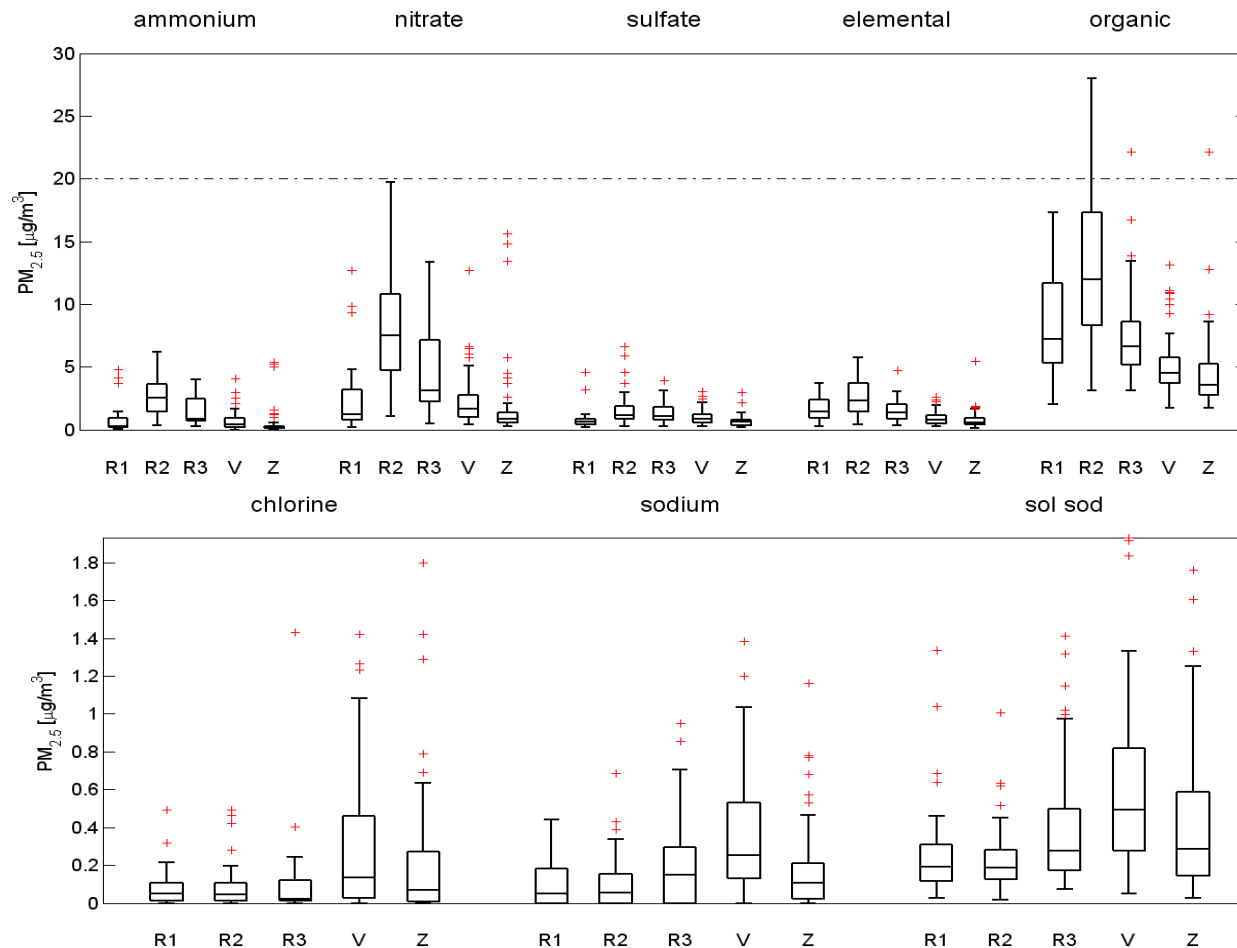
PM_{2.5} Response for Clusters



- PM₁₀ response is similar



Speciated PM_{2.5} Response for Clusters

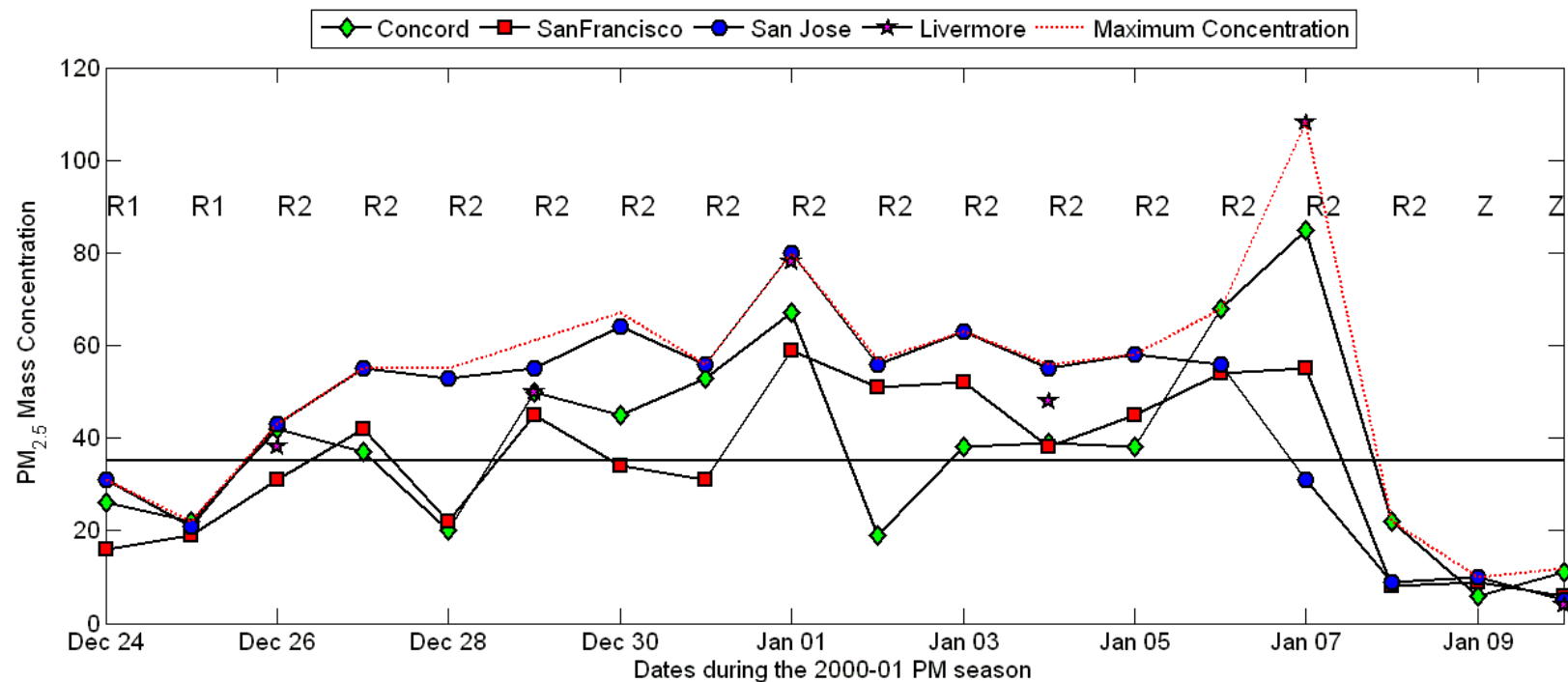


- Dominant species response similar as for total PM_{2.5}
- Cl and Na levels are highest under marine air flows (V and Z)

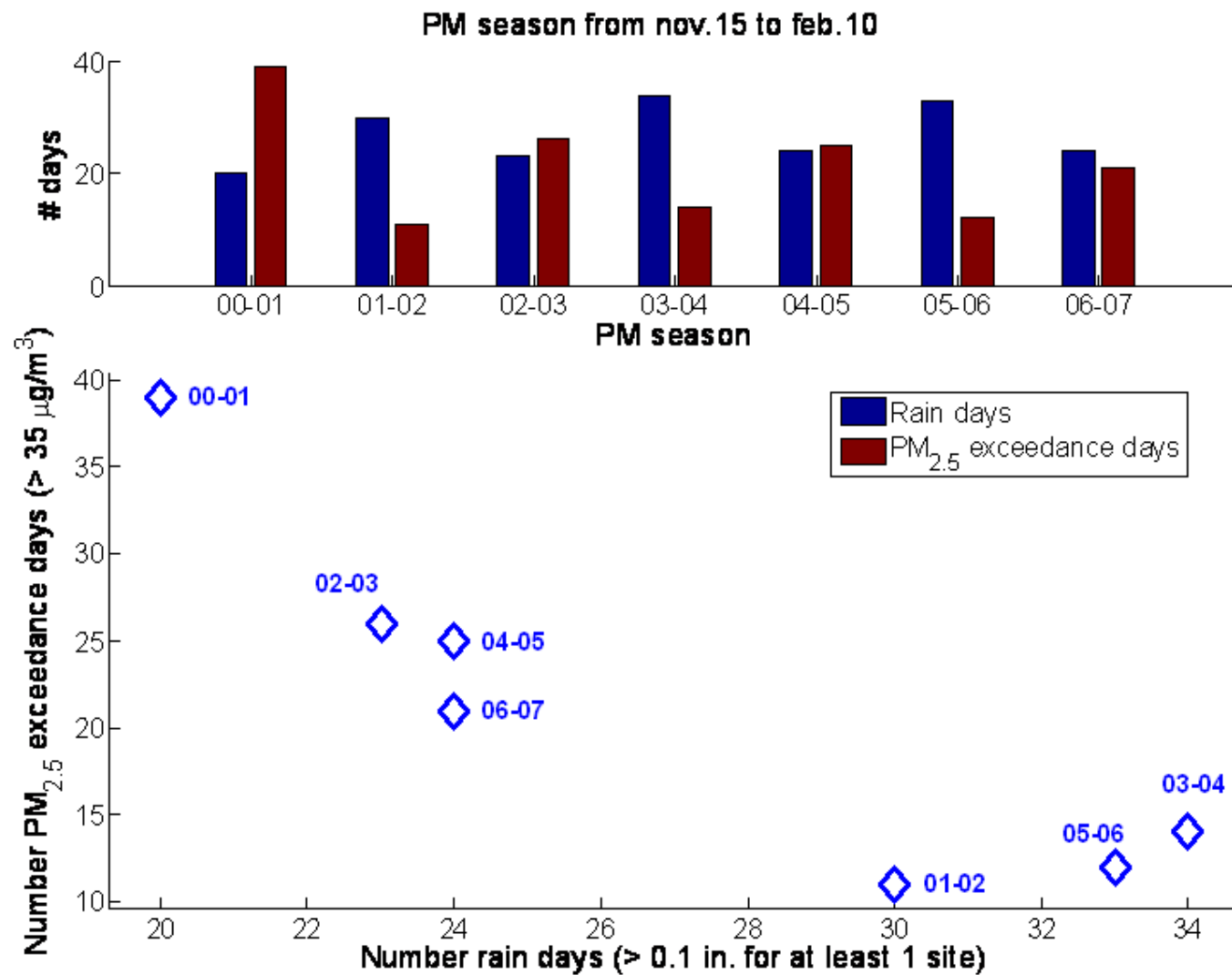


Episode Analysis

- PM levels increase over 2-3 days and level off under conducive conditions
- PM levels rapidly decline upon transition to Z



Inter-annual Trend Analysis



Conclusions and Future Work

- Bay Area PM levels were strongly impacted by meteorology
 - Large scale synoptic influences.
 - Regional thermal effects.
- Total PM levels indicate that dispersion varies by cluster
 - R2 and R3 trigger the bulk of exceedances.
 - R1 has strong winds, but moderate PM levels.
 - V and Z have the lowest PM levels.
- Speciated $PM_{2.5}$ data indicate source-receptor relationships vary by cluster
 - R3 has the highest proportion of secondary $PM_{2.5}$.
 - V and Z have the most sea spray
- PM_{10} response is similar to $PM_{2.5}$.
- Future work
 - Further delineate differences in primary and secondary PM buildup for R2 and R3.
 - Evaluate AQM simulation performance for different clusters.



Cluster Analysis for CCOS/CRPAQS Domain



Proposed Analysis Framework

- Study Domain
 - Independent cluster analyses for 5 basins
 - Sacramento Valley (SV) & Mountain Counties (MC)
 - San Joaquin Valley (SJV)– North, Central, South.
- Study Period
 - Extended PM season (1 November – 31 March)
 - Study period 1996 - 2007
 - Include recent years 2008-09 depending on data availability



CCOS/CRPAQS Study Work Plan

1. Collect, verify and assimilate data (20%)
 - Obtain surface meteorological, air quality measurements and daily weather maps.
 - Surface wind monitor consistency checking using software developed previously at Palazoglu Lab.
 - Design and implement a MATLAB procedure for imputation of bi-variate wind data.
2. Perform surface wind field clustering (30%)
 - Identify static (synoptic) meteorological patterns.
 - Characterize mesoscale flows and other meteorological parameters (temperature, precipitation, etc.)
 - Perform sequencing to identify pathways of synoptic evolution.



Work Plan (Continued ...)

3. Infer relationships between meteorology and PM dynamics (40%).
 - Characterize $PM_{2.5}$ and PM_{10} response under each meteorological condition.
 - Determine the fate of key PM components under meteorological conditions of interest.
 - Infer the effects of inter-annual variability in precipitation events on PM levels.
4. Document and summarize all activities performed and results obtained (10%).



Recent Progress and Future Work

- Pilot Bay Area study will serve as template for the analysis of all CCOS/CRPAQS air basins.
- Steps Completed :
 - Meteorological and air quality data obtained and formatted to be compatible with software.
- Ongoing Activity:
 - Quality assurance of wind measurements is being performed.
- Future Work and Expected Completion Dates
 - Wind field cluster analysis (June – 2010)
 - Meteorological impact on PM dynamics (December – 2010)
 - Final report submission (October-2011)

